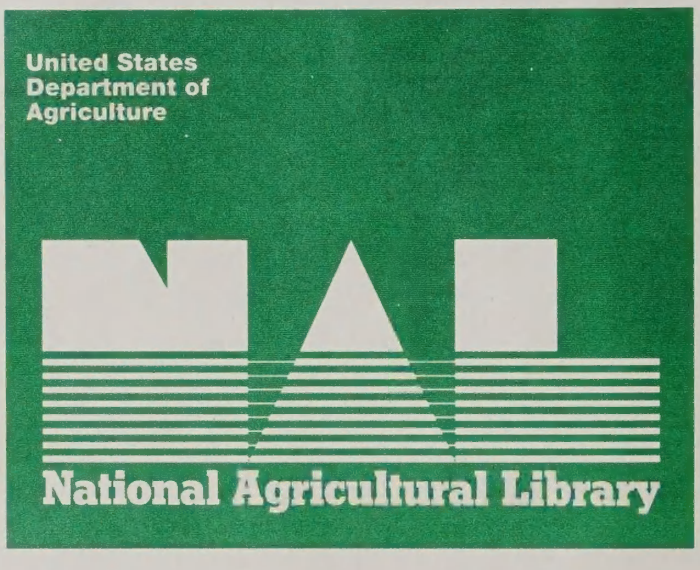
A National Program of Research for

VEGETABLE CROPS

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

February 1969

PREFACE

Authority: The Joint Task Force on Vegetable Research was appointed by the Assistant Scretary of Agriculture and the Chairman, Experiment Station Committee on Organization and Policy, in a memorandum dated April 30, 1968.

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RESEARCH AREAS

The Joint Task Force for vegetable research was instructed to indicate which areas of research need emphasis, and to ascertain the most efficient procedures for organizing and carrying out the specific research. The following Research Problem Areas were assigned to this Task Force.

RPA	Title
204	Control of Insect Pests of Fruit and Vegetable Crops
205	Control of Diseases of Fruit and Vegetable Crops
206	Control of Weeds and Other Hazards to Fruit and Vegetable Crops
304	Improvement of Biological Efficiency of Fruit and Vegetable Crops
305	Mechanization of Fruit and Vegetable Crop Production
306	Systems Analysis in Production of Fruits and Vegetables
402	Production of Fruit and Vegetable Crops with Improved Consumer Acceptability
403	New and Improved Fruit and Vegetable Products
404	Quality Maintenance in Marketing Fruits and Vegetables
501	Improvement of Grades and Standards
503	Physical and Economic Efficiency in Marketing Fruits and Vegetables

The Task Force also considered the following Research Problem Areas, involving research of major significance to the Vegetable Industry:

RPA	Title
102	Soil Structure; and Soil, Plant, Water, Nutrient Relationships
105	Conservation and Efficient Use of Water for Agriculture
106	Efficient Drainage and Irrigation Systems and Facilities
109	Weather Effects, Probabilities, and Agricultural Decision Making
214	Protection of Plants and Animals from Harmful Effects of Air Pollution
601	Expansion of Foreign Markets for U.S. Farm Products
701	Insure Food Products Free of Toxic Residues from Agricultural Sources
702	Protect Food Supplies from Harmful Microorganisms and Naturally Occurring Toxins
708	Human Nutritional Well-Being
901	Alleviate Soil, Water, and Air Pollution

A NATIONAL PROGRAM OF RESEARCH FOR VEGETABLES

The Important Role of Vegetables:

Vegetables constitute a significant part of the total diet of the American population. Probably no other class of agricultural food products are a more integral part of every daily American meal. In contrast to most agricultural crops they are grown exclusively for human consumption, and consequently they are of utmost importance to every American consumer. There is universal concern that vegetables be nutritious; of high quality, and palatable; in adequate supply; and reasonable and comparable to other consumer commodities in price.

The Vegetable Industry is an important part of agriculture. The following table shows its relative importance to other agricultural industries:

Farm Value of Vegetables and Selected Crops

CROP	1939	1967
Truck Crops	$ 284,135,000	$ 1,648,457,000
Potatoes	236,839,000	539,382,000
Dry Edible Beans	46,265,000	143,861,000
Sweetpotatoes	45,340,000	61,204,000
Total Value	$ 612,579,000	$ 2,392,904,000
Wheat	$ 512,427,000	$ 2,120,222,000
Corn	1,465,117,000	4,974,051,000
Cotton (lint)	537,010,000	953,627,000
Sugar Cane and Sugar Beets	- -	390,001,000

The wholesale farm value of vegetables is only one measure of their value to the American economy. The Vegetable Industry forms a sizable basis for the American seed trade; the farm machinery industry; the vegetable freezing, canning, and other processing industries; railroad, airline, and trucking industries; the labor pool for a large portion of the 5 million permanent and transient farm laborers; the retail vegetable markets; the fertilizer and agricultural chemicals industries; and other related industries. To a lesser degree it supports thousands of roadside markets and market gardeners. Accurate assessment of the monetary, nutritional, recreational and health value of home gardens -- to millions of Americans on farms, in villages, and in suburban areas -- is difficult.

The Increased Demand for Vegetables:

The future poses new challenges and opportunities for the Vegetable Industry. It is estimated that by the year 2000 A.D. the population of the United States will reach about 310 million people. The demand for vegetables increases in direct proportion to the growth of population, hence a sharp increase in production will be necessary in the next 3 decades.

In addition to the projected increase in domestic needs, there is a growing export demand. Rapid advancements in processing, packaging, transportation, and marketing have contributed to this rise in export trade. Export indices for vegetables rose from 91 in 1956 to 122 in 1966--an increase of nearly 3 index points per year.

The Vegetable Industry must increase its research programs if it is to meet the challenges of expanding domestic and foreign markets.

The Vegetable Industry: Problems and Trends

Shortage of Labor for Vegetable Production -- Most harvesting, processing, and marketing practices require exceptionally high imputs of labor per unit of product. In the past, the needs of the Vegetable Industry were fairly well met by use of migratory labor, both foreign and domestic. Today, a drop in the number of available migratory workers has created a crisis.

The supply of foreign workers has been sharply curtailed by legislation. And despite rising wages, many domestic workers are reluctant to accept employment in the Vegetable Industry because the work is often hard and long, and done under uncomfortable conditions.

For the Vegetable Industry, the declining labor supply and increased labor costs are primary problems. The rapidly changing labor situation is causing significant shifts within the industry in such areas as source of production, capital requirements, farm organization, and output of individual vegetables. The U.S. farm labor pattern may encourage further increases in imports of vegetables from foreign countries where farm labor supplies are still plentiful.

To attack the labor problem, research on more effective use of remaining workers, and on mechanization should receive top priority. We need to develop a more satisfying economic climate for farm workers through better housing, education facilities, and social services. And to replace departing workers, we must develop machines that can do their jobs. Mechanization in vegetable crops has lagged behind many other crops. The index of production per man-hour for all farm output increased from 86 to 161 during the last 10 years, while the same index for vegetables increased from 92 to 129. Research on mechanization should include: (1) improved machines to prepare, plant, cultivate, protect, harvest, and market the

products; (2) new cultural practices and adapted varieties to meet the needs of mechanization; (3) new concepts of plant protection, processing, and marketing.

Improved Pest Control-- The American Vegetable Industry is keenly aware of its mission to produce crops unblemished by pests, high in quality and palatability, and nutritious and healthful. To advance this important mission, more research is needed in pest control, particularly in the area of biological (or non-pesticidal) methods.

Vegetable Quality in Relation to Processed and Fresh Products -- There is a marked trend toward more processing. Within the next decade an estimated 80% of the entire potato crop will be processed. The following table shows the general changes:

Commercially Grown Vegetables

	Percent of crop fresh	Percent of crop processed
1937	67.6	32.4
1947	59.4	40.6
1957	52.7	47.3
1967	46.6	53.4

This trend shows the need for more emphasis on quality, as well as needed changes in marketing, handling, packaging, and transportation. New techniques and guidelines are needed for assessing quality components, and for improving quality through genetic, cultural, marketing, and handling methods. The trend toward mechanized operations has a marked effect on quality, an effect that must be studied and understood.

The fresh market still requires sizable portions of the vegetable crop. Vegetables such as lettuce are not processed; therefore, improvement of yields, shipping, and marketing procedures have often been more rapid than improvement of quality factors. This is explained by the complexity of quality components and the need of more research.

Fundamental Needs in Vegetable Production and Protection:

Success in producing adequate vegetable supplies largely depends on the steady improvement of vegetables. High quality, resistance to diseases and adverse environmental conditions, pest and weed control, and improved cultural methods are the goals. Current progress is based on the application of basic principles learned in the past in many scientific disciplines. To insure continued progress, research must be increased to solve the problems that now limit significant increases in yields. The fact that much basic research is done by scientists working on vegetable oriented problems does not lessen the need for the assignment of small groups of scientists to explore the unknown. Such groups should be free of the normal pressures that demand quick answers for urgent problems.

The action of the mechanism of the phytochrome pigment in vegetables -- responsible for controlling growth and development -- is unsolved. Yet this pigment is present in large amounts in plants such as cauliflower. The potentialities for chemical regulators are not being fully utilized for the solution of our problems. We need to know how growth retardants affect the behavior of vegetable plants, in order to use these compounds effectively. We must also learn to increase the resistance of plants to extremes of temperature, drought, air pollution, high soil salt content, and other hazards. We need basic information concerning the absorption and translocation of growth regulators and other organic chemicals. Only then can more effective plant regulators and systemic pesticides be developed.

New, more effective, and safer chemicals, and the development of nonchemical methods, are needed for pest control. Currently, there is no satisfactory chemical control for many of the prevalent diseases. Basic knowledge of the disease organism of the host, and of the mechanism of action of pesticides is needed. Not enough is known of the persistence and distribution of pesticide residues, or about their decomposition products, or their effect on quality.

Viruses are among the major classes of diseases that reduce yields. Yet little is known of their structure and behavior in plants and soils.

We must further exploit the genetic potential of plants, and make extensive use of male sterility and other techniques to produce uniform and high yielding varieties. To overcome barriers to increasing yields we need basic studies in quantitative and biochemical genetics. With more emphasis on the basic sciences, new principles may be discovered, to extend the possibility of maintaining and increasing efficiency of production. This would benefit both producer and consumer.

Fundamental Needs in Vegetable Utilization and Marketing:

Quality is generally accepted as one of the most important research goals. Yet its characteristics remain perhaps the most poorly defined. Attempts, to define what is desirable to the customer and why, have been made. Despite the volume of research into customer reaction and quality attributes there is scant information on the subject.

Producers, handlers, and storekeepers are concerned with improving quality of produce. Before real progress can be made, scientists are going to have to define more clearly and in a quantitative way, the concepts of quality--both at the product level and the customer reaction level. Only with such information can the chemist, physiologist, plant breeder, and processor succeed in bringing about the characteristics of high quality in vegetables and vegetable products. Once we know more definitely what we must have, we will achieve ways to devise it. Production, handling, packaging, storage and transportation procedures and techniques can then be modified and improved. Our products will arrive on the market in a more appealing form, and be more palatable and nutritious.

A quantitative understanding of the attributes of quality, and the factors involved in customer acceptance, might well result in an entirely different approach to preservation and packaging. The physical form in which fresh and processed vegetables are presented to the consumer might change. Meanwhile, more emphasis must be placed on basic research in the understanding of quality, and on its attainment and control. Our enlightenment may well prove to be the best technique for sales improvement and customer acceptance.

Hardly less urgent than the need for a study of quality factors is the need for improved marketing practices, and for efficient marketing at all points. Studies for the understanding and improvement of the structure of marketing organizations, as well as ways to improve their operation, or to eliminate the necessity of specific steps in the marketing process, are critically needed and they offer the prospect of substantial savings to the industry.

To expand markets and stabilize prices, new and improved processed products are needed for the domestic and foreign consumer--products that incorporate quality, convenience, stability, wholesomeness, and low cost.

Processing of vegetables reduces cost of preparation time and effort for food consumers. In food service establishments the nearly complete shift to dehydrated mashed potatoes, and the wide use of frozen par-fried potatoes for french frying, exemplify the ready acceptance of labor-saving products in commercial enterprises.

Improved processing methods can accelerate the consumer use of processed vegetables. In 30 years the portion of the crop processed has increased from a third to over half. This trend has made possible a shifting of vegetable production from areas near the large population areas, to more efficient growing areas and practices, wherever they can be developed in the country. Processing stabilizes the quality and food values, and reduces the freight cost and waste.

Importance in Human Nutrition-- Fresh and processed vegetables are major sources of minerals and vitamins. They are generally low calorie foods, a distinct need in obesity diets for "overweight" Americans. They offer the much needed succulence and roughage that are often lacking. The legumes contain proteins needed for a balanced diet, and they are eaten in almost all regions of the world.

SUMMARY OF PROJECTED PROGRAM BY RESEARCH PROBLEM AREAS

	1966 Invent. 1/	1972 TF 2/	1977 TF 2/
Protection Research			
204 Control of Insect Pests of Fruit and Vegetable Crops	76	153	206
205 Control of Diseases of Fruit and Vegetable Crops	139	180	228
206 Control of Weeds and Other Hazards to Fruit and Vegetable Crops	21	36	55
	236	369	489
Production Research			
304 Improvement of Biological Efficiency of Fruit and Vegetable Crops	211	278	400
305 Mechanization of Fruit and Vegetable Crop Production	27	50	71
306 Systems Analysis in Production of Fruits and Vegetables	3	7	9
402 Production of Fruit and Vegetable Crops with Improved Consumer Acceptability	32	35	55
	273	370	535
Utilization Research			
403 New and Improved Fruit and Vegetable Products	86	120	143
Marketing Research			
404 Quality Maintenance in Marketing Fruits and Vegetables	38	42	61

1/ 1966 Base (Vol. 1, table 1, "An Inventory of Agricultural Research")

2/ Vegetable Task Force Recommendations

	1966 Invent. 1/	1972 TF 2/	1977 TF 2/
Marketing Research			
501 Improvement of Grades and Standards	3	9	12
503 Physical and Economic Efficiency in Marketing Fruits and Vegetables	22	33	45
	63	84	118
Subtotal	658	943	1285
Other Research Problem Areas of Concern			
102 Soil Structure; and Soil, Plant, Water, Nutrient Relationships	10	15	20
105 Conservation and Efficient Use of Water for Agriculture	5	10	15
106 Efficient Drainage and Irrigation Systems and Facilities	2	5	10
109 Weather Effects, Probabilities, and Agricultural Decision Making	10	15	20
214 Protection of Plants and Animals from Harmful Effects of Air Pollution	3	10	15
601 Expansion of Foreign Markets for U.S. Farm Products	14	23	25
701 Insure Food Products Free of Toxic Residues from Agricultural Sources	32	47	57
702 Protect Food Supplies from Harmful Microorganisms and Naturally Occurring Toxins	4	8	9
708 Human Nutritional Well-Being	23	46	69
901 Alleviate Soil, Water, and Air Pollution	1	24	36
	104	203	276
Total	762	1146	1561

RESEARCH PROBLEM AREAS FOR PROTECTION OF VEGETABLES

RPA 204 Control of Insect Pests of Fruit and Vegetable Crops:

Developing acceptable controls for insect pests of vegetables has been complicated by recognition of the potential hazards of residues to the consumer, to beneficial insects, and to development of resistance of insects to insecticides. The use of integrated systems of physical and chemical attractants; sterility; cultural controls; parasites; pathogens; host plant resistance; and low residue insecticides has been recognized and encouraged. However, the SMY's available are not adequate for development of these more complex systems.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 204A	Noninsecticidal and Integrated Methods of Controlling Insects on Vegetable Crops	73	113
RPA 204B	Biology of Insects Attacking Vegetable Crops	38	52
RPA 204C	Insecticidal Methods of Controlling Vegetable Insect Pests	42	41
	Total	153	206

TITLE: RPA 204A Noninsecticidal and Integrated Methods of Controlling Insects on Vegetable Crops

SITUATION: Insects cause an estimated $253 million annual loss by direct feeding, by transmission of disease, or by contamination of the end product. Use of insecticides is necessarily heavy, and may result in environmental pollution, residue hazards, and damage to beneficial insects and wildlife. Approximately 5 million acres of vegetable crops are treated with insecticides annually at a cost of about $125 million. Pilot projects on vegetables and other crops have demonstrated, in some instances, the practicality of nonchemical controls such as the use of attractants, predators and pathogens, bio-environmental controls, host plant resistance, and sterility techniques. Integrating chemical controls with nonchemical controls offers even greater probability of success, though little work has been done on specific vegetable crops. (Coordinate varietal resistance research with RPA 205E and 304D.)

OBJECTIVE: To reduce direct and indirect damage to vegetables through use of physical or chemical attractants or repellents; to develop crop varieties resistant or tolerant to insects; to determine the effectiveness of parasites, predators, and pathogens; to devise methods for culturing, dispersing, and enhancing the effectiveness of biotic agents; to determine if environmental modification, including the changing of cultural practices, will reduce pest species; to integrate successful techniques, with judicious use of insecticides where applicable; and to use area-wide autocidal techniques when applicable.

RESEARCH APPROACHES:

A. Identification of pathogens for control of vegetable pests; determination of biological and environmental factors that influence infection in the field, and of the pathogen's potential for mass culture and standardization in terms of virulence for practical application.

B. Identification of the parasites and predators within the pest population; determination of the extent of control exerted by these parasites and predators and the environmental conditions which favor such control; determination as to whether supplementing the natural population through sustained releases of laboratory-reared predators and parasites provides better control of pest insects; development of methods for mass breeding of parasites and predators.

C. Isolation of sex or feeding attractants; determination as to whether insects will successfully compete with natural attractants in the environment; combination of electromagnetic traps and other methods to attai: a degree of population suppression; utilization of knowledge on reflective aluminum and similar mulch repellents, to determine whether this information can be used on a commercial scale.

D. Testing to determine if major vegetable insect pest species can be sterilized by gamma irradiation, or with chemicals; development of mass rearing technology; determination as to use of such techniques in area-wide suppression programs.

E. Collection and evaluation of germ plasm for insect resistance. Incorporation of resistance in adapted varieties.

F. Ecological studies, to determine possible weak links in the biology of pest species that would render them vulnerable to area-wide suppression by bio-environmental control measures such as removal of alternate host plants.

G. Combine promising techniques into integrated systems of control suitable for use by commercial growers.

OMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
73	113

TITLE: RPA 204B Biology of Insects Attacking Vegetable Crops

SITUATION: The breakthroughs which have provided more effective control of insect pests by nonchemical or integrated methods have resulted from new insights gained through additional detailed knowledge of biology and ecology of the target species. Studies of mating habits have revealed the presence of sex attractants; detailed ecological studies have provided information on overwintering ability and overwintering habitat, parasites, predators, and diseases. Such studies, when conducted, have revealed susceptible stages of the life cycle, alternate methods of control and more effective timing of controls. Such detailed information is not available on most of our vegetable pest species.

OBJECTIVE: Gathering background information on the occurrence, distribution, ecology, life history, host range, and physiology necessary to develop new methods of control or make existing controls more effective.

RESEARCH APPROACHES:

A. Establishment of the occurrence, distribution, and abundance of the target species and develop accurate methods of measuring population density.

B. Determination of the seasonal life history, including host-plant sequence, migration, susceptibility to biotic agents, mating habits, reproductive potential, and overwintering habits.

C. Establishment of the economic effect of a population on the host crop and the threshold below which the insect can be tolerated.

D. Determination of the effect of cultural practices on abundance of the pest species.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
38	52

TITLE: RPA 204C Insecticidal Methods of Controlling Vegetable Insect Pests

SITUATION: Chemical control procedures are currently the first line of defense against most vegetable insect pests; and approximately 5 million acres of vegetable crops are treated with insecticides annually. The high per-acre value of vegetable crops often necessitates frequent and heavy applications of insecticides. Effective insecticides which do not persist in the environment are available for some crops. However, most of the available insecticides reduce populations of beneficial insects, and some may be harmful to wildlife. New insecticides must be screened as they become available to identify, if possible, more selective insecticides safe for use but effective.

OBJECTIVE: Development of cheaper and more effective insecticidal control methods that will leave no objectionable residues, destroy few if any beneficial insects, and probably no hazard for higher animals.

RESEARCH APPROACHES:

A. Screening of new insecticides as they become available to find safer, more effective, and selective chemicals.

B. Evaluation of new insecticide formulations, rate and timing of applications, and various types of application equipment, to provide more effective control of target insects and prevent drift of insecticides from target areas.

C. Determination of the residues left on vegetable crops at the time of harvest.

D. Evaluation of the side effects of effective insecticides.

E. Integration of insecticides with other measures such as chemical attractants, light traps, use of pathogens, parasites, predators, or bio-environmental controls to produce more economical control systems with reduced hazards.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
42	41

RPA 205 Control of Diseases of Fruit and Vegetable Crops:

Control of diseases in most vegetable crops is expensive; in others it is imperfect; and for some it is impossible. Growers spend millions of dollars yearly for fumigants, fungicides, labor, and operation and depreciation of machinery, to achieve partial control of fungi, bacteria, viruses, and nematodes that cause diseases. Even so, diseases reduce yields by an average of about 10% annually, while also affecting market quality, shelf life, and palatability.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 205A	Control of Diseases Through Genetics and Breeding	62	75
RPA 205B	Nature of Diseases	38	51
RPA 205C	Crop Sequences, Management Practices and Other Nonchemical Control Methods to Reduce the Incidence and Severity of Diseases	21	35
RPA 205D	Chemical Methods of Controlling Diseases	40	43
RPA 205E	Role of Insects in Transmission of Diseases	15	18
RPA 205F	Identification and Control of Foreign Diseases that May Damage Vegetables	4	6
	Total	180	228

TITLE: RPA 205A Control of Diseases Through Genetics and Breeding

SITUATION: Control of some diseases, such as bacterial spot of tomato and pepper and sclerotiniose of vegetables, is either impossible, under certain conditions, or too expensive. Either disease may reduce yields up to 50% or greater. Genetics and breeding offer satisfactory means of controlling some virus diseases. Chemical control of some nematodes is often unsatisfactory and often reduces yields sharply. Genetic resistance has been identified for a number of vegetable diseases, but not for some of the more severe.

Resistant varieties offer a means of reducing production cost and fungicidal residues, and of increasing both quality and quantity of vegetables.

OBJECTIVE: Identification of sources of resistance to vegetable diseases; and determination of the mode of inheritance, and transference of this resistance to adapted varieties.

RESEARCH APPROACHES:

A. Collection, identification, and evaluation of available germ plasm for disease resistance.

B. Study of inheritance of host reaction to pathogens.

C. Survey of variation in genetic potential of the pathogen.

D. Physiological and biochemical studies of disease resistance.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation	
1972	1977
62	75

TITLE: RPA 205B Nature of Diseases

SITUATION: Fifty or more diseases are described in the literature as occurring on each vegetable. The same pathogen may be the incitant on a number of hosts. Two or more pathogens may be associated with the same infection; the interrelationships of pathogens are not fully known. A better understanding of the life history of the causal agent is necessary, to determine the points at which the pathogen is most vulnerable. When these points are known, more intelligent selection, timing, and application of control practices will increase efficiency and reduce cost of production.

OBJECTIVE: Establishment of pathogenicity, host range, and method of overwintering of pathogens.

RESEARCH APPROACHES:

A. Identification, description, and determination of the host range and environmental factors favoring the development of the pathogens.

B. Study of the life cycle of pathogens.

C. Study of the interrelationships of two or more pathogens occurring on the same host at the same time.

D. Characterization of threshold levels of economic injury caused by pathogens.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
38	51

TITLE: RPA 205C Crop Sequences, Management Practices, and Other Nonchemical Control Methods to Reduce the Incidence and Severity of Diseases

SITUATION: Crop rotation, tillage practices, and sanitation reduce the incidence and severity of many diseases. Some damping-off organisms can be reduced by plowing under dried straw before planting the crop. Flooding the soil for 6 weeks during the summer months rots the resting bodies of sclerotiniose of vegetables. Eradication of certain weeds adjacent to vegetable fields effectively controls some virus diseases. More effective and less expensive nonchemical disease control methods are needed.

OBJECTIVE: Study of disease development on vegetables under different biological, cultural, and nonchemical control methods, and development of more effective recommendations for the control of diseases.

RESEARCH APPROACHES:

A. Study of disease development under different crop sequence patterns, and other cultural methods of disease control.

B. Determination of alternate crops and weeds which may serve as hosts for vegetable diseases.

C. Study of the effect of various cultural practices and biological methods on the microorganisms in the soil.

D. Study of other nonchemical control methods, such as use of hot water, flooding, dry heat, and deep plowing to reduce or eliminate the pathogen.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
21	35

TITLE: RPA 205D Chemical Methods of Controlling Diseases

SITUATION: Larger quantities of chemicals are used on vegetable to control disease than on other crops. Chemicals applied for the control of certain vegetable diseases on some crops are ineffective and expensive. Chemical control of many bacterial diseases, such as bacterial spot of tomato and some root diseases, is impossible or impractical, due to high cost and undesirable residues. Safer, more effective, and economical fungicides, bactericides, and nematicides are urgently needed.

OBJECTIVE: Development of safer, cheaper, and more effective chemical control methods, towards minimum residues.

RESEARCH APPROACHES:

A. Evaluation of new chemicals for disease control in the laboratory and field.

B. Testing of various formulations, rates, times of application, and development of patterns for more effective control of fungi, bacteria, and nematodes.

C. Search for more effective methods and equipment for applying chemicals to soils and plants.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
40	43

TITLE: RPA 205E Role of Insects in Transmission of Diseases

SITUATION: Most vegetables are plagued by one or more diseases transmitted by insects. Since insects are important agents of disease transmission, it is important that the role they play be studied and better understood, so that more effective methods of control can be developed.

Some vegetable crops could be grown in areas where they cannot now be grown profitably. Crop losses could be reduced, and quality improved if more was known about the vectors.

OBJECTIVE: To identify insects transmitting diseases, study the role they play, and develop measures to control the diseases.

RESEARCH APPROACHES:

A. Determination by transmission tests whether insects found in infected vegetable fields are vectors of diseases.

B. Determination of whether pathogens multiply in vector.

C. Determination of longevity of pathogen in vector and movement in fields.

D. Determination of whether feasible to control vector, and if so, determination of whether control of vector controls the pathogen studied.

E. Determination of the number and extent of disease reservoirs in relation to insect vector population.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
15	18

TITLE: RPA 205F Identification and Control of Foreign Diseases That May Damage Vegetables

SITUATION: Fresh vegetables are imported from many countries. Rising labor costs in the U.S.A., and faster and more modern transportation, will increase the importation of fresh vegetables. This will increase the chances of importing foreign disease organisms.

Prior knowledge of the pathogens, and methods of control before introduction, could prevent losses that run into the hundreds of millions of dollars annually.

OBJECTIVE: Determination of potential damage which foreign disease organisms could cause in U.S.A. vegetable-growing areas, and development of methods of excluding or combating them.

RESEARCH APPROACHES:

A. Determination of how well U.S. varieties of vegetables will survive disease epidemics in foreign countries.

B. Study of methods of identification and ways to exclude foreign diseases that would damage domestic vegetables.

C. Initiation of a breeding program to develop lines resistant to those diseases that are most likely to be imported.

D. Study of etiology of potentially dangerous foreign diseases.

E. Cooperation and participation to obtain maximum benefits from international programs.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
4	6

RPA 206 Control of Weeds and Other Hazards to Fruit and Vegetable Crops:

For many weed problems in vegetable production, no satisfactory control measures are available. Some of these problems were met with hand labor in the past, but scarcity of farm labor and increasing costs have forced its abandonment. Weed control systems that require a low labor input must be developed and refined.

The farm labor situation is also forcing mechanization of harvest for vegetable crops. Mechanization is resulting in additional pressure for better weed control. Fields must be relatively free of weeds at harvest time for efficient operation of mechanical harvesters. We must have systems that keep fields free of weeds until harvest.

Modern weed science, a relatively new area of inquiry, does not yet have wide support. There is a strong tendency to increase support of agricultural research along existing lines with a relatively uniform percentage increase. As a result, the small base from which weed science is working tends to be self-perpetuating. Losses, due to weeds and the high cost of weed control, warrant substantial increases in support of weed control research.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 206A	Integration of Weed Control Programs	14	16
RPA 206B	Control of Specific Weeds	7	13
RPA 206C	Behavior and Action of Herbicides in Plants and Soils	7	13
RPA 206D	Application Techniques to Improve Herbicide Performance and Reduce Residues	3	4
RPA 206E	Alleviation of Damage to Vegetable Crops From Weather, Birds, Animals, and Other Hazards	5	9
	Total	36	55

TITLE: RPA 206A Integration of Weed Control Programs

SITUATION: Uncontrolled weeds limit yields and hinder mechanization. The shortage and increasing cost of farm labor are intensifying the need for more effective methods of weed control, with a minimum of labor. We must expand weed control research. Weed populations, soil type, climate, cropping sequence, tillage practices, mulches, and herbicides all need study for development of control. Research results from narrower studies of weeds and weed control will yield their greatest payoff if they are integrated with more general studies, towards more effective weed control systems. Control will result in higher yields; and more efficient control will lower vegetable production costs.

OBJECTIVE: Integration of control systems for specific situations.

RESEARCH APPROACHES: Develop weed control systems in specific vegetable crops. These would include:

A. Determination of the most effective herbicide or combination of herbicides for safe use in particular weed-crop-soil-climate situations.

B. Determination as to, under what situations, plastic and other mulches are economical and superior to other control measures.

C. Evaluation of tillage and other cultural practices as alternatives and supplements to other weed control systems.

D. Evaluation of cropping sequences and systems in relation to their effect on weed control measures.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
14	16

TITLE: RPA 206B Control of Specific Weeds

SITUATION: Control requirements differ from one weed species to another. Thorough knowledge and understanding of weed species is needed. The growth habit, means of propagation, seasonal vigor and growth must all be understood. The susceptibility of specific weeds to herbicides must be understood, as well as the best method of getting a particular herbicide to a vulnerable site of the particular weed. The value of tillage and other cultural practices in controlling specific weeds must also be determined. Irregular and prolonged dormancy is often an important factor in persistence, and it is a limiting factor in eliminating weed seeds from the soil.

OBJECTIVE: A better understanding of the basic biology of the weed species that are important factors in limiting vegetable production; and development of principles and practices for control.

RESEARCH APPROACHES:

A. Study of the life cycles and physiology of harmful weed species.

B. Determination of cultural methods to control development of specific weed species and minimize their return.

C. Evaluation of herbicides for specific weeds, and establishment of the optimum placement and timing of treatment for effective weed control. This would include evaluation of mixtures of herbicides and studies with surfactants.

D. Study of dormancy of seeds and other reproductive parts in selected weed species.

E. Exploration of possibilities for biological control of weeds.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
7	13

TITLE: RPA 206C Behavior and Action of Herbicides in Plants and Soils

SITUATION: The screening of chemicals for herbicidal activity has been largely empirical. More knowledge of plant biochemistry, and of how various chemicals affect plants, is needed to aid in predicting the type of compound needed to bring about a particular plant reaction. Information about mechanism of herbicidal action is needed as a basis for selecting potent combination treatments that are synergistic in their activity against certain weeds. Knowledge of how herbicides affect plants is also needed, to help in the detection and utilization of selective herbicidal action among species. Many herbicides that are applied to the soil do not perform consistently; a better understanding of their interactions with the soil, and of their behavior in soil, is needed.

OBJECTIVE: Development of a better understanding of herbicidal effectiveness, and of the behavior of herbicides in plants and soil. This knowledge will serve as one of the bases for developing control.

RESEARCH APPROACHES:

A. Study of herbicide penetration, absorption, and translocation in plants.

B. Determination of the site of herbicidal action and the biochemical pathways that are disrupted in plants for various herbicides.

C. Study of the behavior of herbicides in soils.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
7	13

TITLE: RPA 206D Application Techniques to Improve Herbicide Performance and Reduce Residues

SITUATION: Improved techniques and equipment for precision placement of exact amounts of herbicide are needed for more efficient weed control, and to minimize herbicidal residues. A requirement for successful chemical weed control is to apply herbicides to the susceptible weed at the proper time and at the proper place. In vegetable production, preemergence applications have many advantages and are widely used. Some treatments require incorporation into the soil.

OBJECTIVE: Development of improved techniques and equipment for precise application for various types of herbicides.

RESEARCH APPROACHES:

A. Determination of more effective techniques of herbicide application to soil. Herbicides that are easily lost or altered soon after treatment need to be given special consideration.

B. Development of application techniques for post emergence treatments that will localize the herbicide on the weeds without injuring susceptible crops.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
3	4

TITLE: RPA 206E Alleviation of Damage to Vegetable Crops From Weather, Birds, Animals, and Other Hazards

SITUATION: Vegetable crops in many areas are vulnerable to miscellaneous hazards, notably frost and damage by birds. Losses from the miscellaneous hazards are erratic and often unpredictable, but they nevertheless account for serious losses. Individual growers often lose entire crops as a result of these hazards.

OBJECTIVE: Development of research results that will serve as a basis for preventing or alleviating injury to crops by weather, birds, animals, and other hazards.

RESEARCH APPROACHES:

A. Development and refinement of methods for minimizing vegetable crop injury from frost and hail.

B. Development of more effective attractants, repellants, and control measures for birds and other destructive forms of wildlife.

(NOTE: Protection of plants from air pollution is included under RPA 214)

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
5	9

RESEARCH PROBLEM AREAS FOR PRODUCTION OF VEGETABLES

RPA 304 Improvement of Biological Efficiency of Fruit and Vegetable Crops:

Vegetable research for the next 10 years should stress the increase of biological efficiency of horticultural crop plants and the decrease of labor required for production, harvesting, and handling. Plant breeders must develop high-yielding varieties resistant to disease and insects, and adapted to mechanical production and harvest. New cultivars of tomatoes, cucumbers, and peppers, for example, will be adapted to machine harvest. They will also have concentrated and uniform maturity for maximum yields in a single harvest by machine.

Cultural and Mineral Nutrition Responses:

Mechanization requires plant density studies to develop changes in production practices that will provide high yields for once-over harvesting. Research on the use of coated seeds and precision planters should aid in reducing preharvest labor. Timing and use of irrigation must be studied to develop procedures for obtaining adequate stands of vegetables and for supplying moisture at critical stages of crop growth. Changes in plant populations and the use of irrigation will require plant nutrition experiments, to establish nutrient levels necessary for maximum profitable production of each crop. Particular attention should be given to the factors which influence the establishment and maintenance of economically satisfactory stands of vegetables under a variety of environmental conditions. Direct or field seeding should be investigated for those vegetables which are now transplanted.

Alteration of Plant Growth and Development by Chemical Methods:

Fundamental studies of the effects of auxins, kinins, gibberellins, growth inhibitors, and growth retardants upon various phases of plant metabolism, growth, and development are needed. Chemicals may be used to thin or increase fruit set, or to concentrate yields of vegetables for mechanical harvest. Some of the new plant growth regulators produce a wide variety of hormone type responses in plants. Many basic plant systems may be regulated or altered by chemicals, depending upon plant species, chemical concentration, and time of application. The effects of chemicals on the physiological processes of each plant species must be determined.

Environmental Effects on Plant Development:

Effects of temperature, light, soil moisture, and photoperiod on vegetative growth, fruit set and development for most vegetables should be investigated. Date of planting and heat unit studies are needed, to modify and predict maturity dates for vegetables. Such information should assist in regulating the production of vegetables and provide an even flow through the season to meet fresh market and processor requirements.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 304A	Seed Physiology and Technology	18	25
RPA 304B	Plant Establishment and Maintenance	60	90
RPA 304C	Management Practices and Nutrition	50	75
RPA 304D	Cytogenetics, Genetics, and Breeding for Higher Yield, Better Quality, Disease and Insect Resistance, and Adaptability to Mechanized Production	100	130
RPA 304E	Regulation of Plant Growth and Development	30	50
RPA 304F	Identification and Modification of Influential Environmental Factors	20	30
	Total	278	400

TITLE: RPA 304A Seed Physiology and Technology

SITUATION: Low yields are often the result of poor seed, lack of seedling vigor, and low tolerance to environmental hazards. Solving the mysteries of seed dormancy, and discovering the conditions that trigger seed germination, would provide methods of accelerating seed germination and improving seedling vigor. Uniform and adequate stands of vegetables are essential for efficient mechanical production.

OBJECTIVE: Investigation of the biochemical and biophysical reactions that occur in seed germination, and utilization of this information to improve germination and quality of vegetable seeds.

RESEARCH APPROACHES:

A. Investigation of germination control mechanisms in vegetable seeds

B. Investigation of effects of environmental variables on seed maturation

C. Investigation of imbibition of water and subsequent metabolic activity

D. Identification of the genotypic and phenotypic factors associated with seed quality: vigor, longevity, and high germinability

E. Investigation of effects of seed production practices on germination, seedling vigor, and subsequent performance of the progeny in crop production areas.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
18	25

TITLE: RPA 304B Plant Establishment and Maintenance

SITUATION: Uniform and adequate stands are of major importance in mechanized production of vegetables. But not enough is known about the influence of soil, climatic, cultural, and mechanical factors on establishment of stands. The efficiency of once-over mechanical harvesting for most crops depends upon concentrated and uniform maturity. Reduced labor requirements should reduce production costs, and benefit producers, processors, and consumers alike.

Research in this approach will be coordinated with effort in RPA 206 and 305.

OBJECTIVE: Determination of the most effective means of establishing and maintaining economically satisfactory stands of vegetables under a variety of environmental conditions.

RESEARCH APPROACHES:

A. Investigation of germination and seedling vigor in relation to time of planting, cultural conditions, micro-environment, and other factors as they affect emergence and stand.

B. Evaluation of methods of planting, types of planting mechanisms, seed coatings, and other means of establishing adequate crop stands.

C. Determination of the effects of seed treatments and seed sizing upon uniformity of germination and crop maturity, weighing biologic and economic feasibility.

D. Determination of optimum and minimum tillage patterns for vegetable crops.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
60	90

TITLE: RPA 304C Management Practices and Nutrition

SITUATION: Once-over destructive harvest inherent in mechanization of most vegetables requires a study of density of plant stands and production practices as they affect yield, quality, and uniformity of maturation. Dates and rates of planting, row width, crop sequences, growth habit, nutrition, irrigation requirements, and other factors should be investigated for maximum profitable production. Management and nutrition practices, adapted to mechanized production, are essential for efficient production. The use of improved methods should greatly reduce hazards of production.

Coordinate with research in RPA 305 and 306.

OBJECTIVE: Determination of optimum plant densities and cultural, nutritional and irrigation practices for production of high yields required for once-over harvesting; development of planting schedules for efficient programming of crop production; and identification of management practices which result in maximum yields in varied environments.

RESEARCH APPROACHES:

A. Investigation of the interactive effects of seed quality, seed and fertilizer placement, time of planting, and climactic conditions on productivity.

B. Development of accurate methods for scheduling planting dates and predicting harvest dates.

C. Evaluation of interaction of plant densities with culture, nutrition, and water management practices in relation to plant growth habit, yield, and quality.

D. Evaluation of crop sequences, plant species for cover and/or intercropping and development of criteria for selection of land best suited for vegetable production.

E. Determination of nutrient forms, concentrations, and placements required for optimum plant growth, yield, and quality.

F. Conduct of nutrition experiments to obtain information on nutrient requirements, (uptake and utilization at all critical stages of growth and development) for optimum yield, quality, and concentrated maturity of vegetables.

G. Investigation of the potential use of Class II land for vegetable production and determination of means towards satisfactorily altered and managed production at a future date.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
50	75

TITLE: 304D Cytogenetics, Genetics, and Breeding for Higher Yield, Better Quality, Disease and Insect Resistance, and Adaptability to Mechanized Production

SITUATION: Increased yields are due in part to improved varieties having disease and insect resistance as a result of genetic studies, and of systematic, carefully executed breeding programs. Improvement in most vegetable varieties is needed for adaptation to mechanized production. Determinate and compact plants, with concentrated and uniform maturity and extended field holding capability, are desirable. Mechanical harvesting demands varieties with good quality retention over a long range of maturity, because harvesting cannot always be accomplished at the optimum time.

Research will be coordinated with studies in RPA 204 and 205.

OBJECTIVE: Development through breeding, of high-yielding vegetable varieties of desirable quality resistant to disease and insects and adapted to mechanized production.

RESEARCH APPROACHES:

A. Development of efficient genetic combinations having seedling vigor, compact and determinate plant types with concentrated and uniform maturity.

B. Incorporation of genes for multiple disease and insect resistance into plant types described above.

C. Investigation of and establishment of factors in production areas relating to varietal and growth efficiency, and determination of whether efficiency may be improved by new genetic combinations.

D. Investigation of basis of heterosis for improving biological efficiency of vegetable plants.

E. Development of more efficient breeding methods for developing F_1 and F_2 vegetable hybrids for commercial use.

F. Development of varieties that have better quality than existing varieties and are capable of retaining quality when mechanically harvested.

G. Development of techniques to evaluate large individual plant populations for tolerance to environmental hazards such as drought, excessive moisture, low light intensity, temperature extremes, and aerial pollutants.

H. Determination of procedures to screen segregating seedling populations for biological efficiency.

I. Investigation of methods of applying specific selection pressures in breeding programs.

J. Conduct research on interspecific and intergeneric hybrids and increase cytogenetic studies to accelerate hybridization.

K. Determination of mode of inheritance of plant and fruit characteristics, linkage, and other genetic knowledge to increase efficiency of breeding programs.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
100	130

TITLE: RPA 304E Regulation of Plant Growth and Development

SITUATION: High yields of high quality vegetables, which exceed processing plant capacities or fresh market needs, may be lost due to obvious limits in harvesting, handling, storage, processing, or marketing capacities for perishable products. Better control of plant growth is of increasing importance with mechanization of crop production. Chemical plant growth regulators which produce a wide range of hormone type responses in plants are known, and new chemicals will be available in the future. The physiological effects of chemical concentration, time of application, and site of application should be determined for each vegetable species. Possibilities for use of growth-modifying chemicals--to thin or increase fruit set, to increase the uniformity of maturity, and alter (lengthen or shorten) the time to maturity--must be investigated. Potential benefits would be of inestimable value in ultimately providing versatile and manageable mechanisms for control of time of harvest so as to better coincide with processing plant and market utilization capabilities.

Research will be coordinated with RPA 305.

OBJECTIVE: Definition of biological and physiological processes that will increase vegetable yields and provide for the establishment of an orderly flow of high quality raw product, in accordance with processing plant capacity or market needs.

RESEARCH APPROACHES:

A. Determination of factors that influence metabolic mechanisms controlling cell division, cell elongation, and cell differentiation.

B. Determination of concentration limits and time of application of growth regulators to favorably influence vegetative growth, flowering, fruit abscission, and fruit ripening.

C. Investigation of methods of applying growth regulators to plant growth sites (roots, buds, leaves, stems, flowers, or fruit).

D. Determination of physiological modes of action of chemicals when they alter or regulate various phases of plant metabolism, growth, and development.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
30	50

TITLE: RPA 304F Identification and Modification of Influential Environmental Factors

SITUATION: Plant growth and crop yield are the result of the interaction of genotype and total environment. Information is needed, to define environmental (climatic, soil, cultural) stresses that limit optimum phenotypic expression of plant growth and yield. Favorable modification of the environment should increase efficiency of vegetable plants to utilize light energy, water, and nutrients in the enhancement of production and storage capabilities.

Greenhouse nutriculture of vegetables with engineered environments offers an opportunity to achieve maximum production per plant. Research should be conducted to improve management practices and to increase automation of greenhouse vegetable production.

Modification and improvement of environmental conditions for vegetable plant growth should maximize yield per unit of area, lower production costs, insure against crop failures, and further mechanization.

Coordinate with research in RPA 109.

OBJECTIVE: Identification of environmental factors that influence attainment of maximum efficiency in vegetable production, and investigation of methods that alter environment favorably.

RESEARCH APPROACHES:

A. Determination of the nature of foliage canopy and plant growth variations in various special arrangements for maximum light interception and photosynthetic efficiency for vegetable plants.

B. Development of management practices for greenhouses to provide maximum carbon dioxide and light absorption and to increase automation.

C. Evaluation of supplemental irrigation and spray mists to supply moisture and favorably modify soil and air temperatures.

D. Determination of effects of plastic films and subsurface mulching upon soil moisture, temperature, and other environmental factors.

E. Investigation of use of protective barriers in areas of excessive wind to improve growth of vegetable plants.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
20	30

RPA 305 Mechanization of Fruit and Vegetable Crop Production:

Availability of labor has become a limiting factor in the production of many vegetables in the U.S.A. Unless machines can be developed to replace hand labor, and reduce the cost of harvesting and handling, the Industry will not be able to maintain its present production, and certainly will not expand. The substitution of equipment for labor offers promising opportunities, through engineering research, to reduce inputs (both dollars and number of workers) required in the planting, growing, harvesting, and handling of crops. High labor requirements for some vegetables contrasts markedly with low requirements for most agronomic crops. Thus, the Industry needs increased research in this problem area to maintain its present position. Achievement of the objectives outlined in three problem sub-areas will require close cooperation with related research in other problem areas and disciplines.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 305A	Precision Planting and Fertilizing	15	25
RPA 305B	Mechanized Harvesting and Handling	30	40
RPA 305C	Harvesting and Processing of Vegetable Seeds	5	6
	Total	50	71

TITLE: RPA 305A Precision Planting and Fertilizing

SITUATION: To insure adequate stands, many vegetables are planted thicker than necessary and are thinned after emergence. This procedure wastes seed and also requires a high seasonal labor input for thinning operations. Procurement of seasonal labor is becoming more difficult and more costly. Chemical weed control eliminates hand-hoeing; and mechanical equipment reduces manpower needs at harvesting. Development of precision planting and fertilizing equipment would not only contribute to the reduction of total labor costs, but would provide more uniform plant growth and maturation of product. A uniform product would allow for simpler harvest mechanization. Small farm machinery companies that manufacture much of the vegetable planting equipment now in use do not have the capital for long-term research, nor do they have adequate contact with biological scientists. Consequently, there is little likelihood that they will pay sufficient attention to development of precision planting and fertilizing equipment.

The research proposed under this activity will be coordinated with that of RPA 102 and 304.

OBJECTIVE: Development of precision planting and fertilizing equipment for vegetable crops to obtain uniform emergence and spacing in the row with no thinning, and to promote uniform plant growth and maturation of product.

RESEARCH APPROACHES:

A. Determination of the soil environment required for optimum germination and emergence of specific crops, and development of equipment to obtain the desired environment.

B. Development of new or improved devices for metering seeds at a uniform rate with or without carrying agents, such as in pelleted form or on tape, and devices for placing these seeds in the soil under conditions most conducive to uniform germination and emergence.

C. Development of equipment to apply fertilizer at the proper time, concentration, and place for optimum growth and uniform maturation.

D. Provision of information on equipment requirements to manufacturers of farm machinery to encourage commercial production.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
15	25

TITLE: RPA 305B Mechanized Harvesting and Handling

SITUATION: Harvesting currently exceeds 400 million manhours of labor. The workers to harvest all of our production are not available. Currently, only 8% of the vegetables for fresh market are harvested mechanically, while at least 40% of those used for processing are harvested by machines. Mechanical harvesting presents a different engineering problem for each crop. Newly developed equipment for harvesting tomatoes and celery reduces labor requirements by 50%, and illustrates the broad potential of mechanized harvesting.

Research proposed under this problem area will be coordinated with that of RPA 304.

OBJECTIVE: Development of mechanized systems and equipment for harvesting and handling vegetables to reduce labor requirements and cost while maintaining yield and quality.

RESEARCH APPROACHES:

A. Development of mechanical methods and machines for harvesting new varieties grown with new production techniques.

B. Development of harvesting and handling systems that will reduce raw product damage and contamination with soil, plant debris, and unusable product.

C. Development of mechanical aids for human pickers that will reduce labor requirements and increase picking efficiency for specific crops where mass harvesting techniques are deemed impractical.

D. Development of field handling equipment and systems that will minimize product damage and be compatible with transportation systems for fresh market or processing outlets.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
30	40

TITLE: RPA 305C Harvesting and Processing of Vegetable Seeds

SITUATION: The United States produced more than 235,800,000 pounds of vegetable seed in 1966 with a value of more than $117,800,000. Some vegetable seeds are harvested with slightly modified grain combines. Other seeds require the use of special threshing machines that often require hand labor to gather the crop and feed it into the machine. This equipment is difficult to clean and it sometimes is responsible for the mixing of seed lots, as well as for transmitting seedborne diseases from infected to clean. Many of the machines now in use are highly unsatisfactory and cause exhorbitant seed losses. Vegetable seeds require far more labor to harvest than cereal and grass seed crops. Because of inadequate harvesting methods there is considerable loss and damage of seed that requires special handling and processing to make it marketable.

OBJECTIVE: Development of more efficient harvesting and threshing equipment and cleaning and separating machines, for on-the-farm processing, towards higher quality seed at a saving to the grower.

RESEARCH APPROACHES:

A. Study of the various components of seed harvesting machines to determine where and to what extent each contributes to seed loss and damage.

B. Design and development of new harvesting machines incorporating special components and techniques which will reduce losses and yield higher percentages of viable seed.

C. Investigation of seed separation methods based on physical characteristics of the seed such as length, width, specific gravity, electromagnetic response, seed coat characteristics, and others which may lead to the design of new equipment to make effective seed separations.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
5	6

TITLE: RPA 306 Systems Analysis in Production of Fruits and Vegetables

INTRODUCTION: Systems analysis for vegetables is part of a more broadly based analysis for entire farm enterprises, including field crops and livestock. The more varied the enterprise, the greater the potential benefits to be derived from systems analysis.

SITUATION: Growers must choose among many alternatives in the selection of crops, varieties, planting time, row spacings, irrigation, disease, insect and weed control practices, and time and method of distribution and marketing. The proper selection from these alternatives should provide for optimum use of labor, capital, and machine capacity, as influenced by weather probabilities, field conditions, and time. Mathematical models, needed for simulation of variables and alternatives in the production system, will permit comparison of the profitability of various alternatives.

In the past, laborious methods of analysis often severely limited the number of comparable alternatives, but high-speed computers and new analytical models have opened the way to more comprehensive analyses of the relevant alternatives in crop production.

OBJECTIVE: Determination of production practices, equipment adaptation, capital investments, and labor availability towards optimum income from vegetable production on individual farms.

RESEARCH APPROACHES:

A. Adaptation or development and use of mathematical models for simulating different vegetable production systems, to identify those factors that require additional research.

B. Tests of hypothetical systems, towards utilization of all known resources of maximum yields. Simulated differences in crops, varieties, nutrients, water, herbicides, and other elements of management will be compared, to determine the most productive and economical combinations.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
7	9

RPA 402 Production of Fruit and Vegetable Crops with Improved Consumer Acceptability:

The necessity for producing vegetables with high consumer acceptance is crucial, despite improved methods of production, handling, storage, and processing. The rapid technological changes taking place in all of these areas of agriculture are constantly creating problems and opening opportunities in the maintenance of vegetable quality.

Quality, a nebulous term, means different things to different people. Quality must be properly defined, identified, measured, and evaluated in terms of consumer acceptance. Its individual components, such as color, flavor, texture, and nutrition, must be more clearly understood before the plant and its product can be manipulated in such a way that optimum quality can be developed and maintained.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 402A	Identification and Measurement of Quality Attributes	10	15
RPA 402B	Genetic, Biochemical, and Physiological Relationships	20	30
RPA 402C	Development of Improved Practices to Achieve Optimum Quality	5	10
	Total	35	55

TITLE: RPA 402A Identification and Measurement of Quality Attributes

SITUATION: Considerable progress has been made in achieving greater objectivity in measuring quality attributes. Continued efforts are needed, and should include additional crops and attributes, standardization of improved methods, and better techniques for rapid and accurate sampling of bulk lots. When necessarily small samples are removed from produce, for destructive methods of analysis or inspection, sampling error can result in faulty assumptions. Quality control of all produce in the lot cannot be assured. Research on nondestructive methods for measuring quality attributes are therefore needed. Unfortunately, quality attributes now in use are not necessarily the quality criteria of the consumers.

Studies in this problem area will be coordinated with research in RPA's 304, 403, and 501.

OBJECTIVE: Development of better objective methods for identifying and measuring rapidly and accurately quality attributes of vegetables, and standardization of objective methods, with particular attention to nondestructive methods.

RESEARCH APPROACHES:

A. Development of objective methods of identifying and measuring quality attributes in vegetables.

B. Standardization of methods for measuring quality attributes in vegetables wherever possible.

C. Development of nondestructive methods for grading vegetables.

D. Development of rapid-accurate sampling techniques for bulk handled vegetables.

E. Equation of quality attributes with consumer acceptance.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
10	15

TITLE: 402B Genetic, Biochemical, and Physiological Relationships

SITUATION: A sound knowledge of the relationship of genetic, biochemical, and physiological factors that affect quality is essential for breeding programs, research on cultural practices, and production planning where maintenance or improvement of quality is a prime consideration. Pigmentation in tomato fruit is a good example of widespread study of these relationships. Studies, particularly of the biochemical and physiological factors, are being initiated on flavor components in other vegetables. Some studies fragment their research effort because they are either genetic or biochemical-physiological in nature. Background knowledge and instrumentation are now available for a more coordinated effort throughout this area of research.

Research will be coordinated with studies in RPA's 304 and 403.

OBJECTIVE: Investigation of the relationship of genetic, biochemical, and physiological factors that affect quality in vegetables, towards more efficient breeding programs and sounder, ecologically oriented decisions.

RESEARCH APPROACHES:

A. Development of germ plasm collections of various quality attributes for specific vegetables and, where possible, development of monogenic lines to more effectively study genetic, biochemical, and physiological factors.

B. Investigation of the relationships of genetic, biochemical, and physiological factors affecting quality in vegetables.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
20	30

TITLE: RPA 402C Development of Improved Practices to Achieve Optimum Quality

SITUATION: Although quality has always been a serious consideration, it is receiving increased attention. New cultural and other production practices and new varieties developed for mechanical harvesting present optimum quality maintenance problems.

Research will be coordinated with RPA's 304, 305, and 403.

OBJECTIVE: Development of production practices that will permit achieving optimum quality.

RESEARCH APPROACHES:

A. Determination of production practices which will result in optimum quality of the final product.

B. Determination of the physiology of quality retention and development of procedures for maintaining optimum quality of the harvested product.

C. Maintenance and improvement of quality along with biological efficiency and growth modifications associated with mechanization.

D. Adaptation of production practices to new and improved vegetable products.

RECOMMENDED RESEARCH EFFORT:

TF Recommendation

1972	1977
5	10

RESEARCH PROBLEMS FOR BETTER UTILIZATION OF VEGETABLES

RPA 403 New and Improved Fruit and Vegetable Products:

Vegetables are perishable and seasonal, and are subject to supply and price fluctuations, to the disadvantage of consumers and producers alike. Processing offers a way to avoid these fluctuations, and to improve diet.

Advance contracting between growers and processors provides an orderly way to avoid price-shattering surpluses disastrous to farmers at harvest time, and at the same time to assure consumers of adequate food supplies at reasonable prices.

To expand markets and stabilize prices, we need new and improved processed products, for the domestic and foreign consumer--products that incorporate quality, convenience, stability, wholesomeness, and low cost.

An important factor to food consumers is the cost of preparation time and effort. In food service establishments, the nearly complete shift to dehydrated mashed potatoes, and the wide use of frozen par-fried potatoes for french frying, exemplify the ready acceptance of labor-saving products in commercial enterprises. Wide acceptance of dehydrated mashed potatoes could save a billion hours of homemakers' time per year.

Processing research can help accelerate the use of processed vegetables. In 30 years the portion of the crop processed has increased from a third to over half. This trend has made possible a shifting of vegetable production from areas near the large population areas, to more efficient growing areas and practices, wherever they can be developed in the country. For example, 60% or more of the tomatoes and 60% of the potatoes for processing are grown in the far Western States. Processing stabilizes the quality and food values, and reduces the freight cost and waste, so that, for most of the year, processed vegetables are lower priced per serving than fresh. At the same time they are nutritious, good-tasting, and more convenient to prepare for serving.

While aesthetic qualities of preserved products are almost always different from fresh, very acceptable quality is available for many processed vegetables. Continuing and needed research is constantly improving consumer acceptance of products by developing new and better products and preservation methods. Constant attention is needed to develop novel methods that will further reduce attendant costs involved in stabilizing and preserving the inherent qualities of vegetables.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 403A	Development of Improved Techniques for Preservation and Stabilization of Processed Products	39	44
RPA 403B	Development of New Vegetable Products	26	29
RPA 403C	Quality Improvement and Characterization of Processed Vegetable Products	41	48
RPA 403D	Evaluation of Processing Characteristics of New Varieties	14	22
	Total	120	143

TITLE: RPA 403A Development of Improved Techniques for Preservation and Stabilization of Processed Products

SITUATION: Vegetable crops in general are perishable and seasonal, and thus are subject to supply and price fluctuations, to the disadvantage of the agricultural economy and consumers. In order to expand markets and stabilize prices, new and improved processes are needed for products that will be desirable to the domestic and foreign consumer from the standpoint of quality, convenience, stability, nutritive value, safety, and cost. The stability of many kinds of processed vegetable needs to be improved, so that the quality and nutritive value will be better preserved during storage and distribution. Processing operations need to be modified to improve quality at lower unit costs despite ever-increasing costs of labor and materials. Reducing the cost of processing is of vital importance, to broaden the market and make the benefits of processing available to consumers at all levels of income.

OBJECTIVE: Improvement of the techniques of processing vegetables to provide better quality, greater stability, lower costs, greater consumer acceptability, and broader markets.

RESEARCH APPROACHES:

A. Development of new processes and adaptation of existing ones, to produce dehydrated vegetable products with porous structure or high specific surface that will promote very rapid reconstitution. Examples of such processes are explosion-puffing; and drum, vacuum, and spray drying; etc.

B. Advancement, and extension to commercial scale, of new consistency controlling juice extraction procedures for tomatoes.

C. Extension of pure culture fermentation techniques to pickled vegetable products as a means of improving quality and curtailing spoilage waste.

D. Determination of effects of freezing rate on quality of frozen vegetables and development of procedures that will optimize freezing rates by utilizing immersion in refrigerants, sprays of liquefied gases, fluidized bed and air lift freezers, etc.

E. Modification of existing processes and creation of new ones to improve efficiency and reduce processing costs.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
39	44

TITLE: RPA 403B Development of New Vegetable Products

SITUATION: Wider distribution and longer periods of availability, as well as reduced cost and improved convenience in use, are required to maintain and build markets for vegetables. High aesthetic and nutritional qualities of vegetables are of great importance in balancing and maintaining adequate diets in the United States. New and improved vegetable products of high quality and moderate cost provide more consumers with these benefits than fresh produce can reach. By preserving and stabilizing the intrinsic qualities of vegetables through processing, production areas of maximum efficiency may be utilized, regardless of the distance from large marketing areas.

OBJECTIVE: Development of new economically feasible products that have improved flavor, texture, appearance, convenience in serving, and other quality attributes, and which are nutritious and highly acceptable to consumers, and which will lead to improved markets for vegetables and improved diets and satisfaction for consumers.

RESEARCH APPROACHES:

A. Study of factors that cause instability of flavor and color in processed vegetables and develop new products of greater stability.

B. Utilization of existing knowledge on the effects of porosity and specific surface, develop new dehydrated vegetable products that rehydrate rapidly enough for convenient quick-service use.

C. Determination of factors that cause discomforting flatulence to people who eat dry beans and devise new products that minimize the adverse effects.

D. Determination of the cause of prolonged cooking requirements for dry beans and peas and develop products that are convenient to prepare and serve.

E. Use of heat and pH control moderate pectic enzymes in tomatoes and thereby develop new products with controllable consistency character.

F. Development of a wide range of frozen and dehydrated vegetable products that can be inexpensively stored in bulk for later formulation into products with easy reconstitution in home and away-from-home kitchens.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
26	29

TITLE: RPA 403C Quality Improvement and Characterization of Processed Vegetable Products

SITUATION: The quality of a processed vegetable product is the sum of these and many other characteristics: flavor, odor, texture, tenderness, consistency, color, size and shape, degree of ripeness, presence or absence of defects, nutritive value, chemical residues, disease and decay producing microorganism.

One quality attribute which has been worked upon but not as much as the chemical and physical factors is the microbiological aspects. Microbial guidelines are needed for frozen vegetables and dehydrated vegetables. Although data have been accumulating, guidelines remain to be established. Each new or improved vegetable product or process presents actual or potential microbial problems. For example, mechanical harvesting of tomatoes introduces microbial problems. Establishment of microbial guidelines will raise and help maintain the quality of frozen and dehydrated vegetables.

Many oxidative changes occur in processed vegetable products (canned, dehydrated, frozen). Some of these oxidative changes produce rancidity, hay-like odors, loss of vitamins and loss of color. Prevention would result in a better quality product.

Quality improvement can be achieved by removal of unwanted chemical constituents (such as the flatulent principle in dry peas and beans) before processing . Valuable chemical constituents, for example, the flavoring components lost during processing, may be added back to the product to improve the quality (adding oil of celery to improve quality of dehydrated celery). Quality of onion powder may be improved by adding a single amino acid, cysteine, as another example.

Problems which still defy solution are the development of objective methods for accessing raw quality and the relation of these to the quality of the finished product. Processed white potatoes are one example.

New and improved vegetable products should be characterized by desirable chemical, physical and microbiological attributes. The amino acid content, trace substances (organic and inorganic), vitamins, minerals, fatty acids and fiber content, should be measured. New processes may change the flavor, texture, color and nutritive values of a product. A more thorough chemical description of vegetables will help the dietician and nutritionist to plan adequate diets for people with special illnesses. Prevention of certain chemical changes that occur in the processed vegetable products could result in the development of more nutritive as well as more

attractive products. Removal of unwanted chemical components and adding back desirable constituents lost in processing can enhance the desirability and acceptance of many processed vegetable products.

OBJECTIVE: Improvement of the quality of existing products. Characterization of the processed vegetable product chemically, physically, and microbiologically to determine if the new or improved processing techniques improve the quality.

RESEARCH APPROACHES:

A. Study and compilation of data for establishing microbial guidelines of quality for processed vegetables.

B. Development of methods to reduce oxidative changes in processed vegetables.

C. Development of methods for removing and/or adding back selected chemical constituents to the finished product.

D. Development of methods to predict the quality of the finished product from objective measurements on the raw product.

E. Describe more adequately the chemical composition of vegetables so that the dietician may make adequate use of these factors in developing diets for the ill.

RECOMMENDED RESEARCH EFFORTS:

TF RECOMMENDATION	
1972	1977
41	48

TITLE: RPA 403D Evaluation of Processing Characteristics of New Varieties

SITUATION: Plant breeders in Federal, State, and private research agencies are continuing to develop new and improved varieties. Production, harvesting, and field-handling practices are being changed. The development of new areas for production of vegetables provides new ecological situations. An increasing proportion of vegetables produced under these changing conditions and situations must be processed, to provide economic advantage or equality with existing sources of supply. To obtain the economic benefits of new developments, research and evaluation are required, to demonstrate that the vegetables produced will meet processors' specifications. Thus, testing for processability is concomitant with introducing new varieties, new methods, and new growing areas. In addition, present processing procedures frequently must be modified to permit handling of raw materials that have new characteristics because of changing conditions and situations.

Research needed along these lines will develop findings essential to the ultimate benefit of research in other areas. For example, improvement of biological efficiency of vegetable crops (RPA 304), mechanization of vegetable crop production (RPA 305), production of vegetable crops with consumer acceptability (RPA 402), and physical and economic efficiency in marketing vegetables (RPA 503).

OBJECTIVE: Evaluation of the processing characteristics of new and improved varieties and selections of vegetables, and achievement of processing research support to agricultural production and engineering research.

RESEARCH APPROACHES:

A. Evaluation of the processing characteristics of new varieties and selections.

B. Evaluation of the processing characteristics of vegetables as affected by changes in cultural and production practices.

C. Development of processing methods suitable for handling vegetables that have been mechanically harvested and subjected to new post-harvest handling methods.

D. Development of new products and processing methods to utilize vegetables of different character resulting from new varietal selections and modified production and harvesting methods.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
14	22

RESEARCH PROBLEM AREAS FOR MARKETING OF VEGETABLES

RPA 404 Quality Maintenance in Marketing Fruits and Vegetables:

Consumers demand high quality, nutritious, and attractive vegetables. Maintaining quality and natural attractiveness from harvest to purchase by the consumer is the goal of growers, processors, and distributors. Consumers will benefit from efforts to reach this goal by getting better quality products. The Industry will benefit by maintaining or increasing consumption and by improving net returns through more efficient marketing.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 404A	Maintenance of Quality During Handling and Packaging	5	9
RPA 404B	Maintenance of Quality During Storage	9	15
RPA 404C	Maintenance of Quality During Transportation	5	6
RPA 404D	Physiology and Control of Post-harvest Functional Disorders, Ripening, and Aging	10	14
RPA 404E	Identification and Control of Post-Harvest Diseases	13	17
	Total	42	61

TITLE: RPA 404A Maintenance of Quality During Handling and Packaging

SITUATION: Mechanization of vegetable harvesting and packaging has in many instances reduced harvesting costs, but also adversely affected the quality, because of greater mechanical damage and increased incidence of decay. Mechanical harvesting may also cause loss of a portion of the crop because of lack of uniform maturity or ripeness. The more numerous injuries and greater susceptibility of the vegetables to decay makes the need for adequate cooling and better packaging more imperative. The type of package, and the packing and loading procedures, frequently restrict air movement to such an extent that undesirable conditions result. Bulk handling, which frequently causes injury, is increasing. Improved handling and packaging procedures and materials would reduce losses of quality that occur during marketing.

OBJECTIVE: To adapt handling and packaging materials and procedures for freshly harvested vegetables that will maintain or improve their quality.

RESEARCH APPROACHES:

A. Evaluation and comparison of the quality of various machine and hand harvested vegetables with emphasis on developing optimum subsequent handling and packaging procedures for the machine harvested commodity.

B. Evaluation of the quality of underripe or immature portion of machine harvested vegetable crop to determine suitability for further handling or utilization.

C. Determination of the effects on quality of handling commodities such as sweetpotatoes in bulk bins or palletized units during operations involving curing, storing, etc.

D. Determination of the effects of various types of packaging on quality during storage.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
5	9

TITLE: RPA 404B Maintenance of Quality During Storage

SITUATION: Although some vegetables may be held for short periods, the practical storage time for most vegetables is very limited. Many fresh vegetables move directly to market with relatively short storage periods consisting primarily of the time in transit. However, some root crops such as potatoes, sweetpotatoes, onions, carrots, and beets, are often stored in considerable quantities for several months. Mechanical harvesting, bulk handling, storage in pallet boxes or bins, and other developments in mechanical handling of vegetables, all influence the storage potential of vegetables, and optimum conditions for storage. Some of the more perishable commodities, such as lettuce, celery, and partially ripened tomatoes, may be stored for several weeks, as on naval supply vessels. Longer storage of fresh vegetables would help stabilize marketing, reduce waste, and increase consumption.

OBJECTIVE: Maintenance of quality in vegetables during a lengthened storage period.

RESEARCH APPROACHES:

A. Determination of the effect of various atmospheres including lowered oxygen concentrations and various levels of carbon dioxide on maintaining quality in stored vegetables.

B. Determination of the effect of varied atmospheric pressures on the quality of vegetables in storage.

C. Determination of optimum temperature and humidity conditions for commodities where technologies are changing such as bulk handling into storage, pallet box or bin storage, and storage of such items as cut seed potatoes.

D. Determination of the effectiveness of chemicals or other treatments on quality maintenance in storage.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATIONS

1972	1977
9	15

TITLE: RPA 404C Maintenance of Quality During Transportation

SITUATION: A change from ice to mechanical refrigeration has brought new quality and disease control problems, because of different temperature and humidity conditions. Recent innovations (such as the use of liquid nitrogen refrigeration and variations in the composition of the atmosphere) raise questions concerning their effects on the quality of the commodity. The rapid growth in air transport of certain perishable fruit may be extended more generally to fresh vegetables in the near future. Air transport of vegetables poses a number of questions concerning types of containers, packages and handling procedures for optimum maintenance of quality. Better environmental conditions during transport would permit delivery of vegetables to markets and result in better quality and longer life on the shelf.

OBJECTIVE: Determination of the effect of present technologies and to participate in developing new technologies for maintaining vegetables in the most acceptable condition during transit.

RESEARCH APPROACHES:

A. Comparison of the quality of vegetables shipped in different types of transport equipment and with different types of refrigerants and controlled atmospheres.

B. Testing of various types and sizes of containers for the maintenance of quality during air transport including handling, pre-cooling, and modified atmosphere effects.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATIONS

1972	1977
5	6

TITLE: RPA 404D Physiology and Control of Post-harvest Functional Disorders, Ripening, and Aging

SITUATION: Research is beginning to reveal a few of the basic mechanisms that govern ripening and senescence in vegetables. Modified atmospheres are being used commercially for lettuce, and to a limited extent, for a few other commodities. Experiments indicate that tomatoes may also respond favorably. The effects of these modifications on respiration, and on other vital processes in the living fresh vegetables, are largely unknown. Ethylene, a volatile produced by most if not all vegetable tissues, has long been recognized as exerting a marked effect on ripening and aging of many plant tissues. Recent research has shown some of the possible precursors of ethylene, and how it may be formed and exert its influence.

OBJECTIVE: Increase in understanding of the vital processes related to quality and to market life of vegetable tissue.

RESEARCH APPROACHES:

A. Study of the respirational patterns of vegetables in various atmospheres to determine which may be most effective in prolonging the life of the tissue.

B. Research on the formation of ethylene in vegetable tissues with emphasis on lipid metabolism and its relation to aging of tissues.

C. Determination of the effects of environmental conditions on the physiology of vegetable tissue as they may be related to quality attributes.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
10	14

TITLE: RPA 404E Identification and Control of Post-harvest Diseases

SITUATION: Diseases are responsible for the substantial loss of quality that occurs during storage and marketing of vegetables. A constant need for identification of diseases, both new and old, exists. Older previously identified diseases may appear with variable symptoms that are not easily recognized by inspectors, and by people without training in pathology. Vegetables imported from Puerto Rico and other areas are often afflicted with diseases that should be identified. Although the benefits of disease control are closely related to the handling, storage, and transit routines, it is desirable to apply specific controls at certain steps in the marketing system, to reduce loss of quality.

OBJECTIVES: Identification of various diseases on vegetables, and establishment of the best controls.

RESEARCH APPROACHES:

A. Identification and development of control measures for post-harvest diseases of domestic and imported vegetables.

B. Study of the physiology and biochemistry of decay producing organisms. This may reveal how organisms cause decay and lead to better methods of controlling decay.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
13	17

RPA 501 Improvement of Grades and Standards:

SITUATION: Inspection of vegetables is mostly visual, and on the basis of external and internal appearance. Present technology affords a potential for savings in time and labor by instrumental measurement of quality characteristics of products. Application of reflectance and transmission spectroscopy, sonics, physical measurements (force-deformation characteristics) and radiometric techniques, psychophysical response to grades and standards, all could enhance objectivity.

OBJECTIVE: Development of inexpensive instrumentation (for reflectance, transmission, sonics, etc., measurement) and psychophysical technology that can be used to accurately and objectively grade vegetable products.

RESEARCH APPROACHES:

A. Evaluation of reflectance and transmission spectroscopic parameters defining quality characteristics of vegetables.

B. Testing of new developments in instrumentation (optical and physical) for application to field and/or laboratory inspection and relate to adaptability to automatic sorting.

C. Development of suitable and safe inspection environments, particularly with respect to adequacy of lighting for inspection of vegetables.

D. Development of objective measuring devices or procedures to determine the physical characteristics of vegetables.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
9	12

RPA 503 Physical and Economic Efficiency in Marketing Fruits and Vegetables:

Physical techniques used to market fresh vegetables have changed little over time. The result has been rising costs to the consumer for products of less than optimum quality, and a decline in the share of the consumer dollar spent for vegetables. Research is needed to determine better ways to handle and condition vegetables for marketing; to adapt new materials and containers for more effective packaging; and to adapt sophisicated transport methods to the movement of fresh vegetables from producer to consumer.

Technological advances, changing consumer preferences, and structural shifts in the marketing system result in constant changes in competitive relationships within the Vegetable Industry. The marketing system can operate efficiently only when those engaged in growing and marketing vegetables have a better knowledge of these changes, and other economic factors influencing their industry.

The proposed support of this research as recommended by the task force is as follows:

		1972	1977
RPA 503A	Improvement in Handling, Conditioning, Storing, and Packing	10	12
RPA 503B	Improvement in Transport Equipment, Techniques, and Packaging	12	17
RPA 503C	Improvement in Market Organization and Structure	11	16
	Total	33	45

TITLE: RPA 503A Improvement in Handling, Conditioning, Storing, and Packing

SITUATION: Each year an estimated 30 million tons of vegetables must be moved from the field to the packinghouse; conditioned; stored; packed; and loaded for shipment to consuming areas. Much of this volume is inefficiently handled and packed by outmoded methods and with obsolete equipment. There is need for research on methods, equipment, and facilities to reduce both labor and nonlabor input requirements and consequent operating costs, through the application of engineering techniques and adaptation of the technological advances available to the Vegetable Industry.

OBJECTIVE: Development of the most efficient methods, equipment, and facilities for conditioning, handling, storing, and preparation for market of vegetables.

RESEARCH APPROACHES:

A. Determination of the labor, equipment, and facility requirements for handling, conditioning, storing, and packing vegetables through the use of engineering research techniques.

B. Development, installation, and testing under commercial operating conditions of new and improved methods and equipment that will increase efficiency of handling, storing, conditioning, and packing vegetables.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
10	12

TITLE: RPA 503B Improvement in Transport Equipment, Techniques, and Packaging

SITUATION: The cost of marketing vegetables in 1967 was $10.2 billion. Cost of labor, transportation, packaging, and containers accounted for over half of the cost. The fresh Vegetable Industry is behind other segments of the food industry in improving packaging, and in adapting unitization and containerization techniques to improve efficiency in marketing. Hundreds of different sizes and shapes of shipping containers for fresh vegetables are in use. Transport vehicles, equipment, and cargo containers and pallets are made in various sizes and shapes. Research is needed to develop and evaluate the most efficient packaging, transport equipment, and techniques, and to adapt the potential benefits of the use of modular shipping containers, unitization, and containerization to the movement of vegetables from growers to consumers. Although some fresh vegetables such as carrots and cauliflower are trimmed and packaged at the point of production, many vegetables, such as head lettuce and asparagus, are not usually trimmed or packaged until they reach retail stores. Performance of these services at point of production coupled with protective packaging would help reduce the cost of marketing and reduce losses. This work will be coordinated with similar work being done and planned under RPA 601.

OBJECTIVE: Increased efficiency in packaging and transporting vegetables, to reduce damage losses, retain nutrients, and increase consumer acceptability and demand by more attractive and useful packaging.

RESEARCH APPROACHES:

A. Improvement of design of transport equipment, packages, and containers; testing in laboratories and under actual marketing conditions for efficiency of performance.

B. Measurement of productivity of labor, cost of materials and equipment, space occupied in transport and storage and other cost elements associated with the use of newly developed packaging, equipment, and transport techniques in comparison with conventional or control packages, equipment, or techniques.

C. Determination of market acceptability for new packages and containers, transport equipment, and techniques and effects of using them on condition and salability of the product.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
12	17

TITLE: RPA 503C Improvement in Market Organization and Structure

SITUATION: Important changes are taking place in vegetable marketing, in response to varied economic forces. The number of growers is declining rapidly but individual farm operations are expanding. Growers must sell to fewer but larger firms. Mass merchandising, and the shift to direct negotiations between producer and retailer, have had a major impact on traditional marketing groups. The central market concept in our large metropolitan areas has decreased in importance. Consumers' demands are changing, particularly with respect to quality, convenience, and form of products desired. Marketing costs have increased. Research is needed, to determine the adjustments that growers, marketing, and processing firms should make to successfully meet changing economic environments. The introduction of more efficiencies in the marketing system will alleviate cost/price pressures on producers and consumers.

OBJECTIVE: Development of information on economic factors that will improve operation of the marketing system.

RESEARCH APPROACHES:

A. Analysis of the economic organization of the vegetable marketing system, by individual commodities and groups of commodities. Emphasis should be given to analyses of trends and current status regarding number and size of firms, extent of integration and contractual relationships, competitive practices, and the overall effect of these factors on prices, incomes, and market performance.

B. Formulation and evaluation of the alternative approaches to improve the economic efficiency of the marketing system, including studies focusing on the role and potential of farmer cooperatives.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
11	16

OTHER RESEARCH PROBLEM AREAS OF CONCERN TO THIS TASK FORCE

TITLE: RPA 102 Soil Structure; and Soil, Plant, Water, Nutrient Relationships

SITUATION: The importance of research in this area and its potential application to vegetable production strongly suggests careful consideration and coordination of research efforts among soil scientists, agricultural engineers, olericulturists, and others. The intense nature of vegetable production--and the rapid development of technology leading to mechanization of production, harvesting, and handling of vegetables--emphasize the need for research that relates attributes of soil structure to fundamental soil, plant, water, and nutrient relationships. Mechanized production increases the importance of soil structure, which influences seed germination, emergence, nutrition, and physiological functions relating to productivity and uniformity in plant development. All these factors require increased attention.

Development of machines to replace human labor has placed added importance on soil structure and its relation to efficiency in machine performance and its effect on crop growth. The movement of heavy equipment through the fields in the many steps associated with production and harvesting has an obvious influence on soil structure. Therefore, it affects the ability of the soil to maintain optimum plant, water, and nutrient relationships for plant growth.

The critical importance of achieving high productivity and uniformity in growth and maturity of vegetables for mechanical harvest increases the importance of the soil and its physical and biological properties, which in turn influence crop response. Because many vegetables are well adapted to only limited geographical areas and soil types, we must learn more about the relationship among soil factors and plant responses, and about ways to perpetuate or enhance soil productivity. We should identify and develop ways to modify those features of soil structure that limit plant responses. We may be forced to use soils that are not now economically practical for vegetable crop production.

OBJECTIVE: Determination of those features of soil structure that directly or indirectly influence uniformity in seed germination, plant emergence, plant growth, and productivity, and which develop practical methods for ameliorating soil conditions that contribute to variability in individual plants.

RESEARCH APPROACHES:

A. Development of procedures for identifying and modifying attributes of soil structure that influence uniformity in seed germination, seedling emergence, and plant growth.

B. Development of soil management practices that will alleviate or minimize the adverse effects of agricultural equipment on soil structure and therefore on water penetration and movement, aeration, nutrient availability, and root growth.

C. Development of soil management procedures that will facilitate utilization of agricultural equipment in harvesting activities as soon as desirable after a rain.

D. Development of procedures for management of soils now unsuitable for vegetable production that would permit their commercial use in the future.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
15	20

TITLE: RPA 105 Conservation and Efficient Use of Water for Agriculture

SITUATION: Substantial competition for existing water supplies, among industries, cities, and other interests outside of agriculture, increases the need for economical use of water by agriculture. Increased cost and declining availability of labor require development of economical, automatic systems that may conserve both labor and water. Development of techniques to conserve and enhance efficiency of water use is encouraged.

Unpredictable, intermittent droughts, often for extended periods, place a widespread, simultaneously heavy demand on water sources. Yet an adequate supply throughout the growing period is essential to quantity and quality crop production. Information, on the capacity of existing and future water sources, as well as on methods for conserving water to be used for crop production, is needed. If soil moisture is deficient for a brief time, at any critical point in plant development, yields and quality of many vegetables can be seriously affected. Adequate moisture is essential for uniform seed germination and establishment of proper stands. Moisture stress at the time of flowering and "fruit" set in green beans, peas, and similar crops may seriously limit yields. Ultimate quality and yields of all vegetable crops can be adversely affected, if moisture becomes limited at any time during the growing season. Rising land and labor costs, coupled with increased financial investment in equipment, fertilizer, and agricultural chemicals in the production of vegetable crops, will necessitate the use of supplemental irrigation as an "insurance" factor in production.

The need for adequate quantities of continuously available "high quality" water for irrigation of vegetables in arid areas is an established fact. Irrigation is also essential in producing vegetables in humid, relatively high rainfall areas of the U.S.A. Whether mechanized vegetable crop production can be successfully maintained without dependable supplies of irrigation water is doubtful. All factors related to conservation and efficient use of water in crop production should be considered. Special attention must be given to the problems peculiar to vegetables such as the intense cultural practices followed and special requirements for high yields and uniformity in maturation of a perishable crop.

OBJECTIVE: Determination of requirements of the Vegetable Industry for water--particularly with respect to quantity and quality in humid production areas; and development of efficient methods for insuring an adequate and continuous supply.

RESEARCH APPROACHES:

A. Development of improved procedures for determining frequency and quantity demands by vegetables for supplemental irrigation in humid production areas.

B. Identification and evaluation of management practices, varieties, and environmental factors that influence efficient use of water through all stages of crop development.

C. Assessment of various techniques that may be employed to reduce moisture loss from the soil and plant surfaces without detrimental effect on crop yields and quality.

D. Evaluation of the practicality of using water derived from food processing plants, and other secondary sources for irrigation of vegetable crops.

E. Determination of the minimum water quality requirements for supplemental irrigation of specific vegetables in different soil and climatic environments.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
10	15

TITLE: RPA 106 Efficient Drainage and Irrigation Systems and Facilities

SITUATION: Efficient drainage and irrigation systems and facilities have a direct bearing on biological efficiency, productivity, and mechanization. Although the need for, and use of, irrigation in arid regions of the U.S.A. need not be defended, improved systems that will reduce labor requirements and improve efficiency in water distribution, application, and drainage, require further research.

Use of supplemental irrigation for vegetables grown in humid areas of the United States is increasing. The advent of mechanical harvesting increases the importance of irrigation. Present investments in land, equipment, fertilizer, and agricultural chemicals add incentive for use of supplemental irrigation, to insure high yields and crop quality.

Intensive and specialized cultural practices require use of much larger quantities of fertilizer and pesticides than are normally needed for the production of agronomic crops. As increasing national attention is paid to eutrophication and siltation of natural water resources, the special problems created by rainfall and irrigation practices on the clean-cultivated, row-cropped vegetables deserve special attention. Methods and procedures of irrigation and drainage must be developed, to minimize the movement of soil, pesticides, and fertilizer elements from resident sites. Olericulturists should be consulted on the special problems of the Vegetable Industry relating to research on drainage and irrigation systems and facilities. Close coordination of effort with RPA 105 is essential.

OBJECTIVE: Development of drainage and irrigation systems and facilities for efficiency and high productivity in mechanized vegetable production.

RESEARCH APPROACHES:

A. Development of improved irrigation equipment that will conserve both labor and water.

B. Development of cultural systems that will prevent surface run-off of water from cultivated fields and the associated movement of soil, nutrients, and pesticides into water courses.

C. Exploration of new and improved methods for determining irrigation water requirements.

D. Exploration of new concepts and ways of irrigating vegetable crops in both arid and humid production areas with special emphasis on subterranean systems.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
5	10

TITLE: RPA 109 Weather Effects, Probabilities, and Agricultural Decision Making

SITUATION: Weather is a major variable in its influence on vegetable yields and quality. Only recently, however, has there been any detailed information on rainfall, frost dates, and temperature for development of planting schedules, crop maturity predictions, disease and insect control practices, and harvest schedules. Not until even more recently have there been procedures to identify, appraise, and modify features of the microclimate which influence certain plant responses. The development of broader weather modification capabilities could provide additional ways to improve production management, and to attain consistent, dependable yields of high quality vegetables.

Compared to most agronomic crops, most vegetables achieve optimum quality at a certain time; and since they remain at this stage only momentarily, they must be harvested within a matter of hours, if their peak commercial value is to be realized. In the past, successive hand harvests permitted selectivity and a longer harvest period. But present practices, on a once-over harvest principle, are more critically related to, and influenced by, weather phenomena as these affect simultaneous achievement of maximum yield and maximum quality. Because of increasing capital investments in land, equipment, fertilizer, and agricultural chemicals, vegetable growers need accurate and timely weather prediction.

Commercial vegetable production is concentrated in geographical regions, according to climatic adaptation of the species. In many cases, frosts and hail restrict development of commercial vegetable production. Because many thousands of acres of good agricultural land are lost each year to industries, highways, and urbanization, we must consider use of some of these meteorologically unsuitable areas in the future. Procedures for modifying weather will be important in making them useful for vegetable production. Meteorologists and climatologists should work cooperatively with olericulturists in solving these problems.

OBJECTIVE: Development of meteorological information and reporting systems that will permit more timely and efficient use of weather data in the programming of vegetable production.

RESEARCH APPROACHES:

A. Definition of weather factors that influence vegetable development, and design more efficient systems for collecting and disseminating weather data needed in programming vegetable production practices.

B. Development of methods for field modification of microclimate to achieve maximum production and quality.

C. Development of models that will appropriately measure and weigh weather phenomena and permit projection of their influence on crop yields and time of maturity.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
15	20

TITLE: RPA 214 Protection of Plants and Animals from Harmful Effects of Air Pollution

SITUATION: Atmospheric pollution is now a serious problem for plants as well as for man. Acute smog conditions around major sources of pollution, such as metropolitan Los Angeles, New York, and London, have been well publicized, but the fact that plants are susceptible to injury from the photo oxidants in smog is not nearly so well recognized.

Commercial crops of spinach have been lost in California, and photochemical injury has been confirmed on beans, onions, tomatoes, squash, cantaloups, sweet corn, Swiss chard and eggplant. Economic losses from crop injury by atmospheric pollution has assumed commercial importance to the Vegetable Industry today.

OBJECTIVE: Determination of the specific and interactive effects of various atmospheric pollutants on the growth, development, yield and quality of vegetables and development of means for reducing their effects on vegetable production.

RESEARCH APPROACHES:

A. Analysis of components of polluted air to determine their chemical composition and properties.

B. Study of the effects of each individual pollutant, and combinations of pollutants, on the growth of vegetables.

C. Determination of which vegetable species are most tolerant of atmospheric pollution.

D. Development of and selection of varieties with high tolerance to air pollutants.

E. Investigation of methods for protecting plants from pollutants.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
10	15

TITLE: RPA 601 Expansion of Foreign Markets for U.S. Farm Products

SITUATION: Factors of urbanization and economic specialization, and the growing affluence that led to the trend for increased use of processed vegetables in the U.S.A., also exist in other hard-currency areas of the world--particularly in western Europe and Japan. Vegetables available for only a short part of the year, in fresh form, are now acceptable throughout the year in processed form, if the price is reasonable and the quality is good. High prices caused by high cost of some processes and high import duties limit sales of processed vegetables in Europe.

A large foreign market for leafy vegetables, and for fresh tomatoes, green beans, sweet corn, and celery, has not been developed, because of the difficulties of packaging and transporting them abroad at low cost and in acceptable condition. New packaging and transport techniques--such as low cost and lightweight packaging materials, unitization, container ships, and jet freighter airplanes--offer opportunities for reducing packaging, handling and transport costs, and for obtaining faster delivery to permit sale of fresh vegetables in good condition in foreign markets.

Frozen foods have had a small market in Europe because mechanical refrigeration has not been available in a large percentage of stores and households and because selling prices have been high. Hence, these processed vegetables seldom reach the mass market, and are bought by a relatively small, affluent segment of the population.

For the mass market, costs and prices must be low and products must be stable at ambient temperatures. Dehydrated vegetables offer an opportunity to get into the mass market abroad. Quality in many products must be improved, to grasp that opportunity. The economies of dehydration processes are substantial and become more so with increasing distance from vegetable producer to market. Furthermore, stability of product quality also becomes more important, because of the time increase between packing and consumption. Stable dehydrated vegetables constitute a small but important export market for vegetable producers in the U.S.A. Future growth of this market will be materially influenced by improved quality and greater stability of products.

OBJECTIVE: Development of packaging and transport techniques and equipment that will enable delivery to foreign markets of fresh vegetables in acceptable condition and at low cost; and development of technology to produce export vegetable products of high quality and good stability.

RESEARCH APPROACHES:

A. Designing of improved transport equipment, packages, and containers and testing them in laboratories and under actual marketing conditions for efficiency of performance.

B. Measurement of productivity of labor, cost of material and equipment, space occupied in transport and storage and other cost elements associated with the use of newly developed packaging, equipment, and transport techniques, as compared to conventional or control packages, equipment, or techniques.

C. Determination of market acceptability for new packages and containers, transport equipment and techniques and effects of using them on condition and salability of products.

D. Development of new and more economical ways to dehydrate and finish-dry vegetables to very low moisture levels to improve stability.

E. Identification of acceptable antioxidants to protect dehydrated vegetables against oxidative changes.

F. Development of processes, products, and packages that will permit delivery of high-quality frozen vegetables to foreign markets at reduced cost.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
23	25

TITLE: RPA 701 Insure Food Products Free of Toxic Residues from Agricultural Sources

SITUATION: With increasing public concern about pesticides and their effect on human life, wildlife, beneficial insects, and role in environmental pollution, the need for information concerning pesticide residues in soil, in or on crops, and in the environment is urgent. Vegetable growers currently rely on the use of pesticides for control of insects and mites, nematodes, diseases, weeds, and rodents, and also as plant growth regulators and defoliants. The Industry annually uses approximately 35 million pounds of active ingredient of various pesticides to protect vegetable crops. Pesticide use is regulated by Federal and State agencies, to assure that the chemicals perform their function effectively, and that crops are safe and free of toxic residues. However, better methods and more information are needed to insure that crops will be free of excessive residues, but yet insure that growers will have effective materials approved for pest control.

OBJECTIVE: Development of methods of determining pesticide residues in soil, vegetable crops, and associated products, and methods of eliminating or reducing to minimum acceptable levels in or on vegetable crops.

RESEARCH APPROACHES:

A. Evaluation of new and existing pesticide chemicals including research to determine whether their use will result in the appearance of measurable residues of the compounds or their metabolites in harvested vegetable crops and if residues do appear, determine the amount and rate at which they are eliminated or broken down into harmless substances.

B. Development of specific methods for isolation and identification of pesticide chemicals and their metabolites.

C. Development of methods of pesticide application considering formulation, timing, rates of application, placement, and other techniques designed to minimize or eliminate residues on crops.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
47	57

TITLE: RPA 702 Protect Food Supplies from Harmful Microorganisms and Naturally Occurring Toxins

SITUATION: In addition to preventing spoilage, preservation processes for vegetables must assure freedom from infectious microorganisms or toxins produced by microorganisms. For example, the severity of canned food heat process schedules is determined by the difficulty of killing heat resistant bacterial spores. Minimum heat processes are designed to insure destruction of the deadly toxin-producing Clostridium botulinum. Most low-acid vegetables must be processed in pressure retorts at temperatures of 240-250° F. for periods up to an hour or more, depending upon product and can size. This severe processing results in some loss in the quality and acceptability of canned vegetables. Some vegetables are not canned in commercial quantity because of the serious loss of textural quality that results from the necessary heat processing.

A rapidly growing segment of the food industry is prepared foods (frozen and dehydrated) that can be conveniently reconstituted in home and food service kitchens. Special precautions are required to provide assurance that such products are safe to use over a broad range of conditions of reconstitution. Frozen pre-cooked foods may be under-heated. Foods with dehydrated vegetable ingredients may be reconstituted over long periods of time at room temperature. It is essential that such prepared foods and the ingredients from which they are made are free from harmful microorganisms and naturally occurring toxins.

OBJECTIVE: Development of new processes, for preserving vegetables, less damaging to freshness than the existing processes, and for equivalent protection from harmful microorganisms and naturally occurring toxins.

RESEARCH APPROACHES:

A. Development of new processes for canning vegetables and other low-acid foods through studies of the nature and control of heat resistance of bacterial spores.

B. Development of processing procedures to eliminate from dehydrated vegetables Salmonella, Staphylococcus, and other infectious or toxin-producing organisms.

C. Development of methods to control sanitation in food processing plants to reduce microbial contamination including pathogens from processed foods.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION	
1972	1977
8	9

TITLE: RPA 708 Human Nutritional Well-Being

SITUATION: Vegetables are important sources of nutrients, especially minerals and vitamins. Although vegetables vary in chemical composition (and therefore in nutritional value), some generalizations are possible.

All vegetables contain some carbohydrate, part of which is in the form of sugar or starch. Part is present as cellulose and pectic substances which are not digested by the human body, and hence valuable as roughage. All fresh vegetables are high in water, ranging from 73% for sweet corn to 96% for head lettuce.

With the exception of vegetables such as the dried legumes, most vegetables are low in protein. The protein content ranges from approximately 1 to 2% for tomatoes, carrots, winter squash, and lettuce to 6% for young green peas, and 8% for young green lima beans. The amount of fat or oil in vegetables is usually very small. For example, cauliflower, carrots, and tomatoes have only 0.2%, turnip greens and winter squash 0.3%, and sweet corn 1.0% fat. Vegetables contain no cholesterol.

The dark green leafy vegetables--mustard greens, turnip greens, collards, kale, spinach, and chard are high in iron, vitamin A, vitamin C; and they also contain other minerals and vitamins. Vegetables classed as bulbs--roots and tubers, as potatoes, beets, turnips, carrots, and rutabaga--contain relatively large amounts of starch or sugar, as well as small amounts of other nutrients. Some supply a good amount of vitamin C. It should be noted that carrots have unusually high vitamin A value. Broccoli and cauliflower, classified as flowers and buds, are very good sources of vitamin C, and contribute other nutrients as well. Seeds, even when immature, are notable sources of the B vitamins and iron. Included in this class are immature lima beans and peas. Many of the vegetable fruits--including cucumbers, peppers, tomatoes, pumpkin, and others--are especially valuable for one or more nutrients. Tomatoes and green peppers, for example, are good sources of vitamin C.

The nutritional qualities of fresh vegetables can be maintained or lost from time of harvest through marketing channels and storage, and in final preparation in the home, restaurant, or institution.

Technological advances have yielded new forms of processed vegetables. These include the freeze-dried; concentrated, fully and partially prepared; pre-packaged portion controlled; and convenience forms prepared outside of the home, restaurant, or institution kitchen. Technology will continue to adapt new processes to other vegetables. Processing alters the nutritional values of vegetables in varying degrees.

Genetics and breeding offer means of controlling some diseases of vegetables, offer means of increasing future yields and means of controlling vegetable quality. These approaches can also be used to develop strains of vegetables that can physically withstand the rigors of mechanical harvesting, transportation, and long storage. Improved nutritional quality of vegetables may be built in genetically in varieties of the future.

OBJECTIVE: Maintenance and improvement of the valuable nutritional contributions of vegetables for human well-being.

RESEARCH APPROACHES:

A. Followup of changes in fresh vegetables from harvest to the table, to determine the procedures needed to bring highly nutritious and palatable vegetables to the consumer.

B. Study of processed vegetables on a continuing basis for their nutritional quality, with special attention to the effects of new processing techniques. Changes during processing and changes during storage of the processed product should be included in these studies.

C. Analysis of vegetables to insure that newly developed varieties have equal or improved nutritional qualities to those now available. Studies of these values should be made on all promising new variety developments.

D. Analysis of vegetables to identify nutrients that may be present, but that have not yet been determined.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
46	69

TITLE: RPA 901 Alleviate Soil, Water, and Air Pollution

SITUATION: Pollution problems, created by current methods of disposal of waste products from the vegetable processing industry, could influence adversely the future welfare and expansion of the industry. Besides the problem of increased waste for disposal, there is the complication of diminishing underground water supplies. Yet irrigation, recreational, industrial, and domestic needs are increasing to the extent of reducing the water in streams, and of slowing the rate of flow, even in our largest rivers. Serious pollution of streams in major processing areas creates health hazards, mars the beauty of the countryside, and modifies the ecology to the detriment of plant and animal life. Increasingly local, State, and Federal regulatory agencies are pressing the food processing industry to end stream and air pollution. As the industry expands, the problem grows in seriousness.

The present vegetable pack exceeds 18 billion pounds annually, and gives rise to more than 7 billion pounds of waste annually. Liquid effluent from processing plants is sometimes handled in municipal sewers, but seasonal high BOD loads from processors cause serious upsets in the operation of municipal treating plants. Population growth is also overloading municipal treating plants in many areas. Where sewers are not available, processors handle effluents in a variety of ways. Some are discharged continuously into streams; others are ponded and discharged into streams during periods of high flow rates. Both aerobic and anaerobic lagooning are used to reduce BOD in the effluents before they are discharged into streams. Spray irrigation is also practiced. These methods have serious drawbacks. Land is frequently not available or is of the wrong type for spray irrigation. Ponding and lagooning seldom reduce the BOD to the levels which are considered safe by Federal standards. Odors from anaerobic lagooning create an intolerable nuisance in population centers.

OBJECTIVE: Development of the technologies that can reduce the quantity of waste that arises from vegetable processing, and adjustment of the pollution of effluents to levels compatible with the Federal pollution control regulations, at costs that will allow vegetable processors to retain markets for their products. Such costs are reduced, where possible, by recovery of available values, including food or feed products and reusuable waters.

RESEARCH APPROACHES:

A. Development of new processing methods and plant cleanup procedures to reduce the waste effluents and increase their concentration so they can be more efficiently processed.

B. Development of improved methods of treating concentrated waste streams and recover values therefrom.

C. Development of methods for treating and handling dilute waste streams from processing.

RECOMMENDED RESEARCH EFFORT:

TF RECOMMENDATION

1972	1977
24	36

SUMMARY AND CONCLUSIONS

I. Value as a Commodity

In 1967 vegetable crops had a reported farm value of $2.5 billion. This represented about 11.2 percent of the total value of all farm crops (21.9 billion). Among crop commodities, vegetables were in third as a source of farm income, being ahead of food grains, fruit and tree nuts, tobacco, and cotton. They were sixth in rank among all agricultural commodities, exceeded only by cattle and calves, dairy products, feed grains, hogs, and oil bearing crops.

II. Industry Trends

The increase in demand for vegetables is directly related to the increase in population. The per capita consumption of fresh and processed vegetables has remained stable at about 200 pounds for the last 20 years.

The amount of commercially grown vegetables processed has nearly doubled in the last 17 years:

	1950	1967
	(million tons)	
Processed	5.9	11.7

Yields per acre have increased markedly in the last decade:

	Total Acreage (1,000 acres)	Total Production (1,000 tons)	Tons per Acre
1957	3,685	16,951	4.6
1967	3,564	20,989	5.9

This progress in production efficiency has resulted from combined factors of improved cultural methods, increased specialization in production, shifts in geographical areas of production, changes in varieties grown, and marked changes in crop utilization. National yields of potatoes per acre have doubled every decade for the last 3 decades.

III. Diversity of Problems in Vegetable Research

The Vegetable Industry is based upon the production, processing, and marketing of many diverse crop plants. A total of 31 crops 1/ are included in annual statistical reports by the U.S. Department of Agriculture. It is estimated that more than double that number of vegetable crops are grown commercially for which no statistics are available. A recent published list contained 190 plant species used for vegetable production.

Each vegetable crop has its own unique problem. In addition the research needs of a crop bear little relation to the total size of the crop. Consequently the overall research needs of many small crops, if met fully, would require a manifold expansion of present national efforts.

Production is widely dispersed geographically and subject to a great range of soil, climate, and cultural practices. Because of differences in physical characteristics and ultimate use of individual vegetables, there is much variation in production, handling, and processing requirements.

IV. Research Opportunities and Needs

To fulfill its mission of increased needs for fresh and processed vegetables, both at home and abroad, many challenges face the Industry. Among the problems which urgently require further research are:

(a) Mechanization of production, processing, and marketing practices to reduce labor inputs. Research should include

(1) Improved machines to prepare, plant, cultivate, protect, harvest, and market the products;

(2) New cultural practices and adapted varieties; and

(3) New concepts of plant protection, processing, and marketing.

1/ Artichokes, asparagus, lima beans, green snap beans, dry beans, beets, broccoli, brussels sprouts, cabbage, cantaloups, carrots, cauliflower, celery, sweet corn, cucumbers, eggplant, escarole, honeydew melons, garlic, kale, lettuce, onions, green peas, dry peas, peppers, potatoes, shallots, spinach, sweetpotatoes, tomatoes, and watermelons. Mushrooms, a major vegetable, are not reported.

(b) Improved pest control - insects, diseases, weeds, birds, and animals.

(c) Increased research emphasis on quality including techniques for assessing quality components, and for improving quality through genetic, cultural, marketing, and handling methods.

(d) Research to provide for the rapid expansion in vegetable processing.

(e) Improved consumer acceptance through modified and improved techniques and procedures of production, handling, packaging, storage, and transportation.

(f) Improved environment management to exploit the potentials of photosynthetic efficiency.

(g) Entirely new systems of plant improvement to break out of plateaus.

(h) Increased research on conservation and efficient use of land and water for vegetable production.

(i) Research on protection of the crops from weather, natural hazards, and harmful air, soil, and water pollution.

(j) Expansion of foreign markets by increased research on processing, packaging, transportation, and utilization of vegetables and vegetable products.